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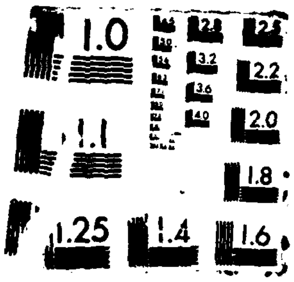
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DIRECTLY MEASURED CURRENT PROFILES IN THE EAST AUSTRALIAN CURRENT (U)

By

P.J. MULHEARN

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DIRECTLY MEASURED CURRENT PROFILES IN THE EAST AUSTRALIAN CURRENT

P.J. Mulhearn

ABSTRACT

Some direct measurements of current profiles in the East Australian Current are presented. They were obtained with profiling current meters from a drifting ship. The velocity shear in the current meter results is considerably larger than that calculated by the geostrophic method.

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1. Introduction

On two cruises on board HMAS KIMBLA various oceanographic measurements were obtained of the East Australian Current's front near 30°S, where the current flowed southwards just east of the shelf-break. Most of the measurements are discussed in Mulhearn (1986). As part of this investigation some profiling current meter stations were occupied in the frontal zone, with the aim of comparing directly measured current profiles with those obtained indirectly via the geostrophic balance.

2. Equipment

The profiling current meters used on the two cruises were of the electro-magnetic type and were hung from the horns on the bow of HMAS KIMBLA (See Fig.1). Data were monitored and recorded digitally, with a 1 Hz sampling rate, on board, during a station. Currents were measured relative to the ship, as it drifted under the influence of wind and current. It was assumed that the wind and the currents at all depths were steady during a station. The ship's speeds and directions were estimated from whatever satellite navigation fixes came in during the course of a station. A Magnavox Satellite Navigator MX1102 was used.

On the first cruise (26 Nov - 03 Dec 1982) the current meter used was originally designed at Woods Hole Oceanographic Institution and further modified by Mr R.F. Halliday of the Department of Mechanical Engineering, University of Sydney. On the second cruise (27 May - 02 June 1983) a current meter designed by Dr Ian S.F. Jones of RANRL was used. It was similar to the Richardson Number probe of Jones and Bruzzone (1981) except that it had only one current sensor which was 10 cm in diameter, rather than 2.5 cm. Both current meters were fitted with pressure and temperature sensors. Two successful stations were obtained on each cruise.

3. Averaging Time

During a test run with the profiling current meter on the first cruise, it was held at a depth of 145m±1m for 45 mins while the ship drifted between 30°16'S, 153°31'E and 30°20'S, 153°27'E. Successive five minute averages of speed and direction relative to the ship, and of temperature are shown in Fig. 2. Overall average relative speed and direction were 16.9 cms^{-1} and 57.4° with standard deviations of 3.1 cm sec^{-1} (18% of the mean) and 9.2° respectively. For ten minute averages, which were used in this work, standard deviations between ten minute samples (taken over four samples) were 2.6 cm sec^{-1} (16% of the mean) and 9.5°.

4. Results

The positions of the two stations, A and B, on the first cruise (Nov-Dec 82) are shown in Figs. 3(a) and (b). Both are east of the surface front on its warm side, with A right at the front at 250 m, and B still further east. The front at a given depth is here defined as the region where the isotherms are closest together at that depth.

During the second cruise (May 83) the front was moving westwards. Station C (302035-302210(Z) May 83) was taken just east of the surface front while station D (310010-310200(Z) May 83) was taken further east again [See Fig. 4(a)]. Both these stations were taken west of the front at 250 m [See Fig. 4(b)].

Using the ship's surface drift, the absolute velocity profiles were estimated. These are shown in hodograph form in Fig. 5. At station A, very close to the front's position at 250 m, there is less variation in speed but more in direction than at the other stations. The reason for

this difference is not known. Speed and direction profiles are shown in Fig. 6. The vertical velocity gradients are much bigger at stations C and D, than at A or B. C and D were taken east of the surface front but west of the front's location at 250 m depth, and this is a region of large horizontal change in density structure. Velocities relative to a deep measurement at each station are presented in Fig. 7. Again variations in direction are greatest at station A. No clear relation was found between vertical changes in velocity and temperature profiles, which are shown in Fig. 8.

5. Comparison with Geostrophic Velocity Profiles

On the first cruise a series of XBT's was dropped across the line of drift of each current meter station (see Fig. 3(a)). From these and the temperature-salinity curves of Pearce (1981), dynamic heights relative to 450 m were calculated. Then from a linear regression between the temperature at 450 m and the difference in dynamic height between 450 m and 1300 m (Pearce, 1983), the southward components of geostrophic currents were calculated relative to 1300 m. Note that the shapes of geostrophic current profiles are more reliable than their absolute values, because 1300 m is probably not a level of no motion. The expected r.m.s. error in geostrophic velocity differences between 0 and 450 m is approximately 20 cms^{-1}. In Fig.9(a) the southward components of the geostrophic and directly measured currents from the first cruise are compared. The shallow increase in velocity with depth seen on the directly measured profiles is not seen on the geostrophic ones, and the directly measured shear at station B is much larger than that in the geostrophic profiles. These differences may be due to ageostrophic effects in the frontal zone, though

the low near-surface velocities in the directly measured profiles may be due to the proximity of a large metal ship to the electromagnetic velocity sensor. The differences in magnitude, rather than shape, are probably due to inaccuracies in the method for calculating geostrophic velocities.

On the second cruise the front was moving westward between the time stations C and D were occupied, and an XBT section was obtained across the front just north of 30°S, after leaving station D. (See Fig. 4(a)). The profile of the southward component (actually towards 190°E) of the geostrophic velocity thus obtained is compared with the directly measured southward component in Fig. 9(b). Again velocity shear is considerably larger in the latter, below 25m. In this case the geostrophic velocities are relative to 250 m depth, because of the shallow water-depth at the western end of the XBT section.

The theory of Kao (1980), which was applied to the Gulf Stream front, found that the along-front flow was close to geostrophic, except near the free surface where diffusion became important. As one would expect diffusion to reduce velocity gradients, the higher shear in the directly measured profiles is puzzling, but may be caused by internal, inertial-gravity waves.

Acknowledgements

Thanks are due to Messrs B. Jones, J. Boyle, F. Bruzzone, G. Maskell and S. Pascoe of RANRL who assisted on the two cruises and to Mr L. Hamilton who helped with computing. The officers and men of HMAS KIMBLA are also thanked for considerable help on the cruises.

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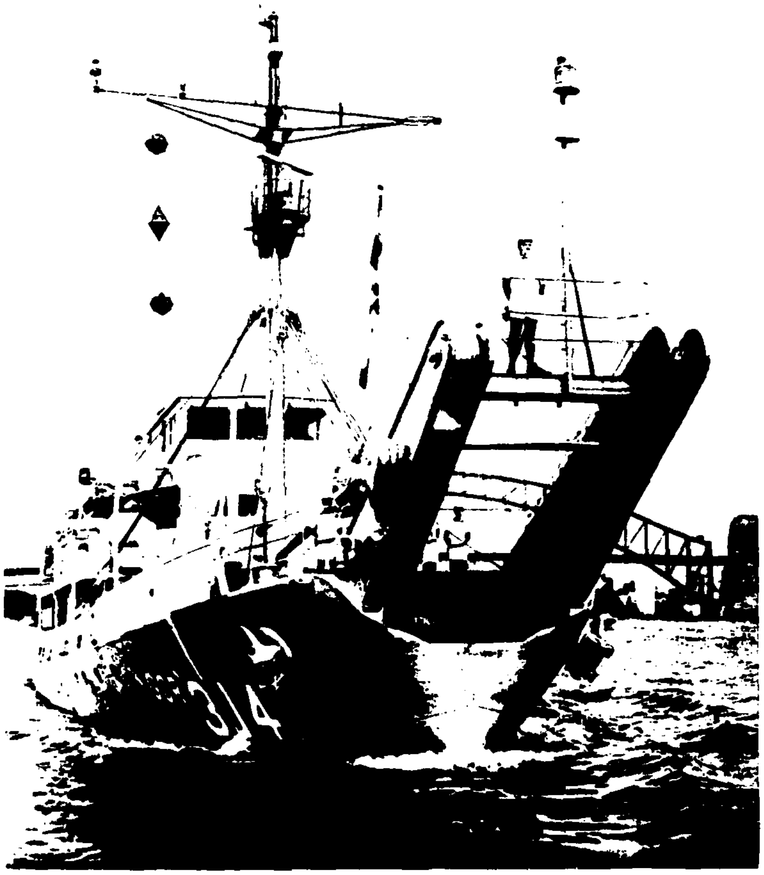

Fig. 1. H.M.A.S. Kimbla, showing horns at bow.

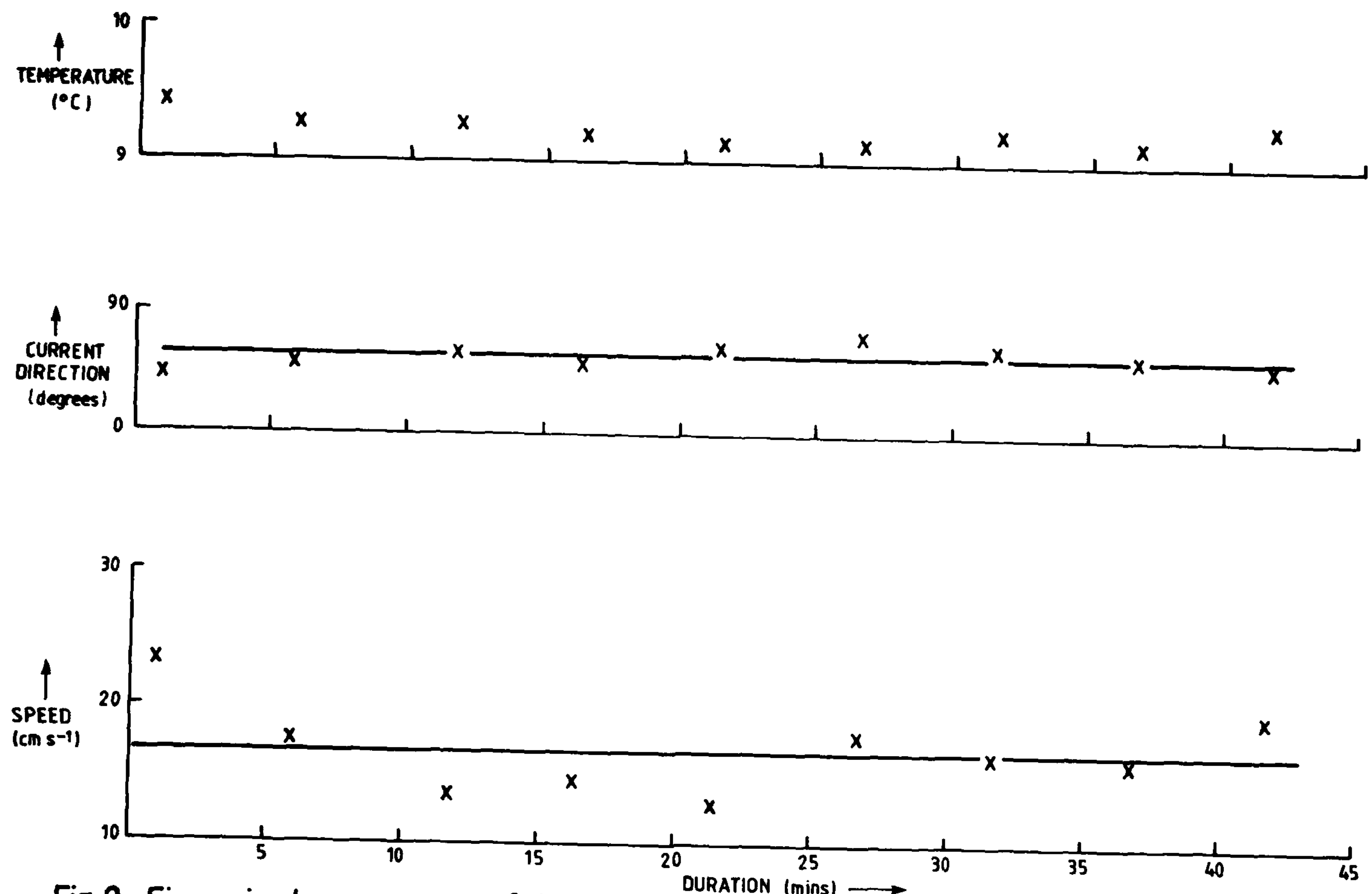

Fig.2. Five minute averages of temperature, current direction and speed vs time.

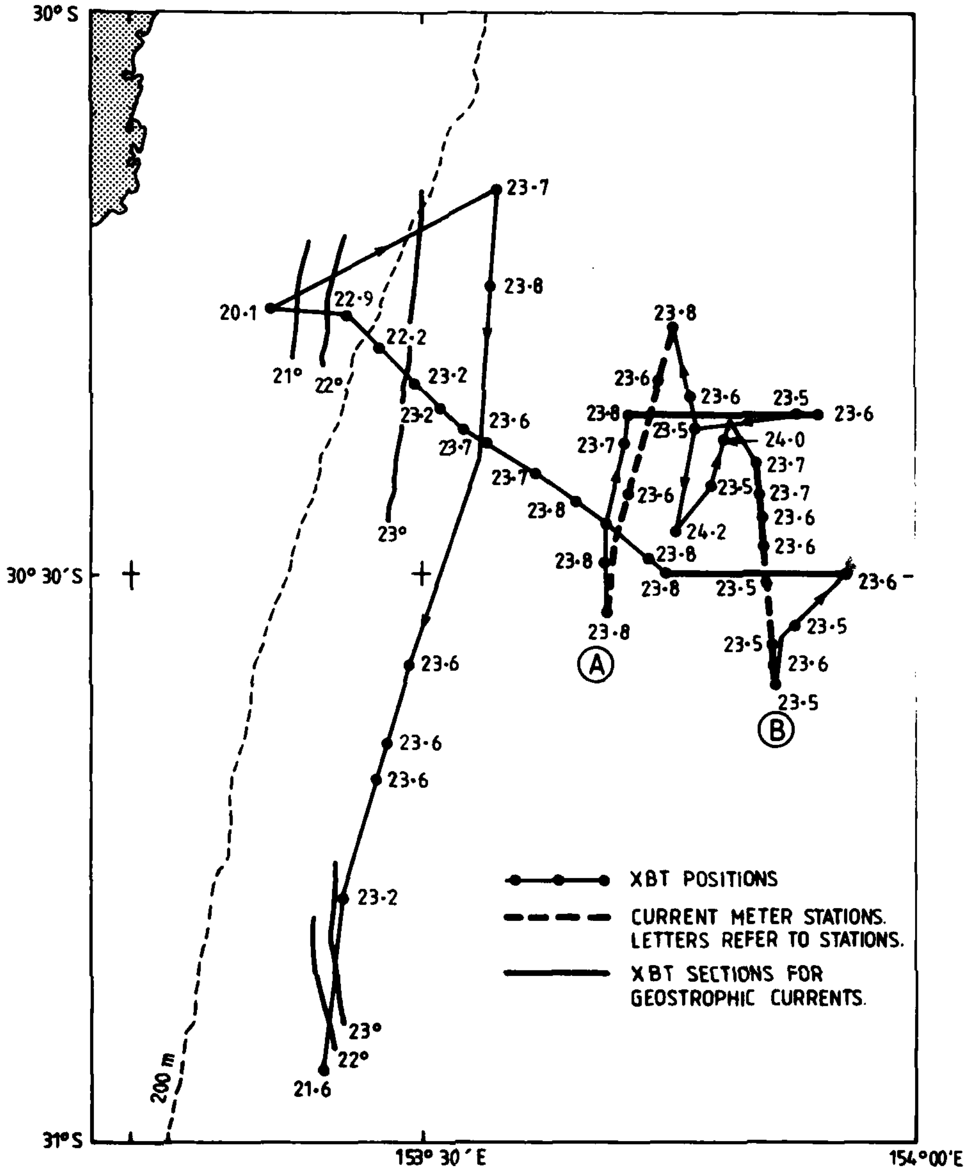

Fig. 3 (a). Sea surface temperature during first cruise. (290635Z Nov. - 010500Z Dec. 82).

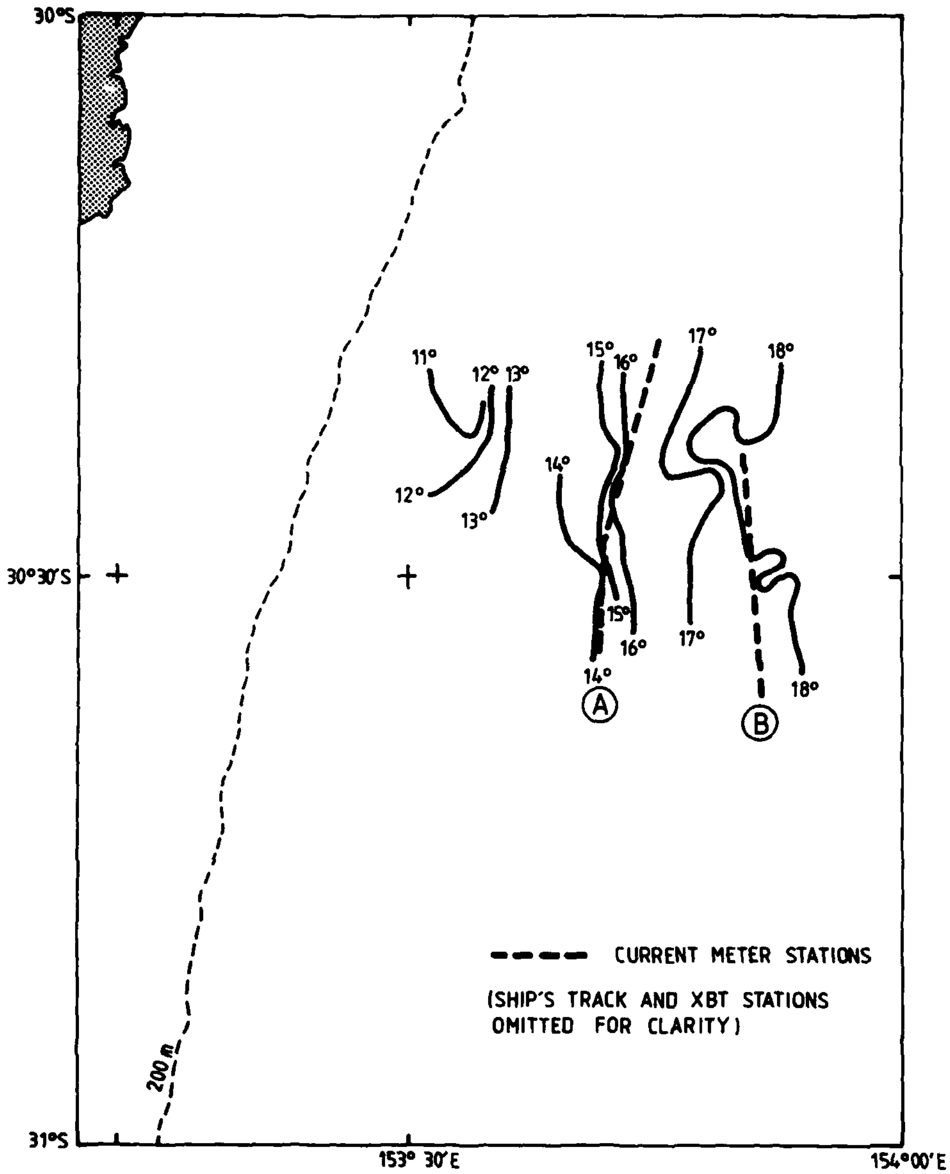

Fig. 3 (b). T_{250} (°C) contours during first cruise 290635Z Nov.- 010200Z Dec. 82.

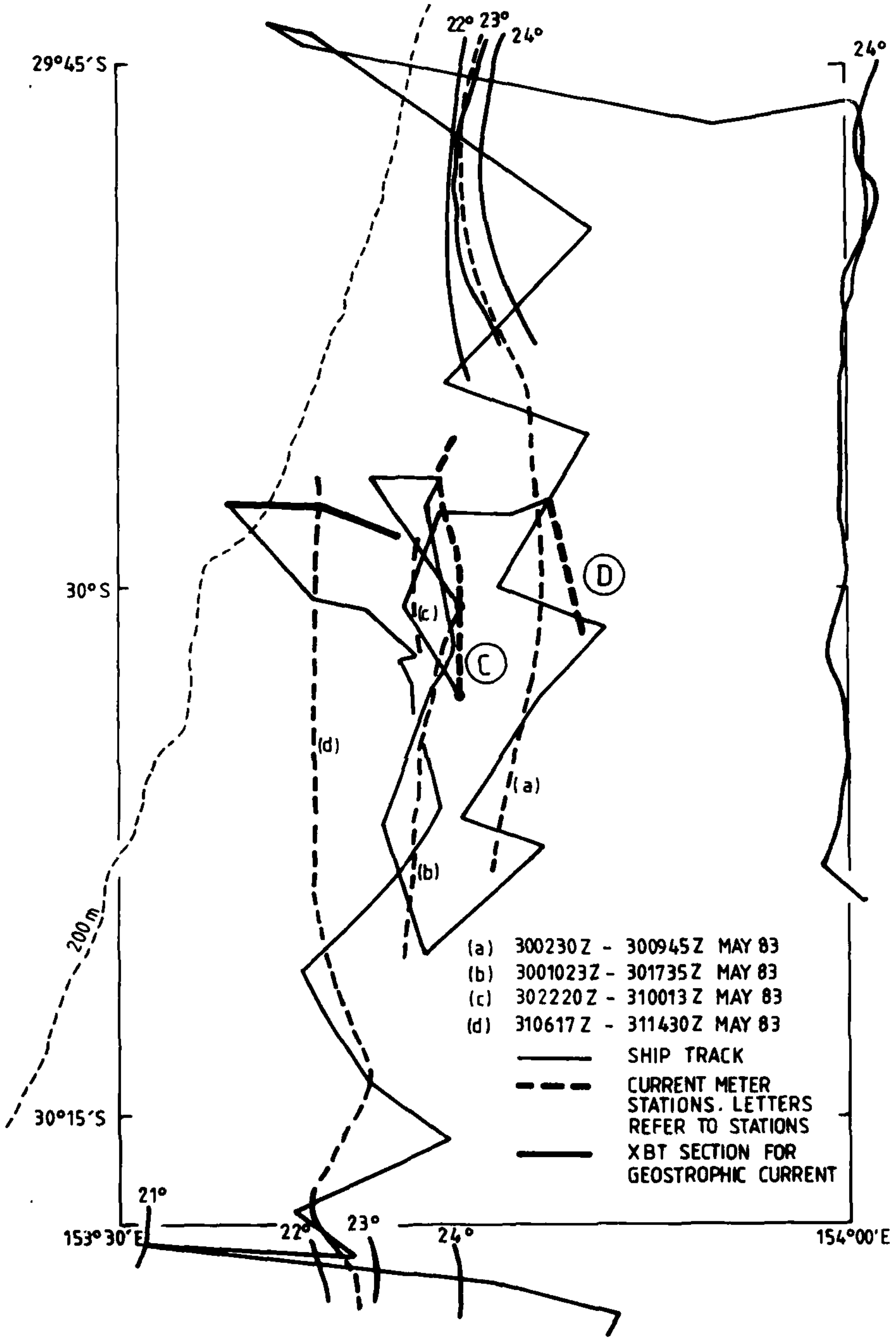

Fig. 4(a). Frontal positions from Second Cruise (with SST's off XBT's). Dashed lines indicate positions of the front over specified time intervals.

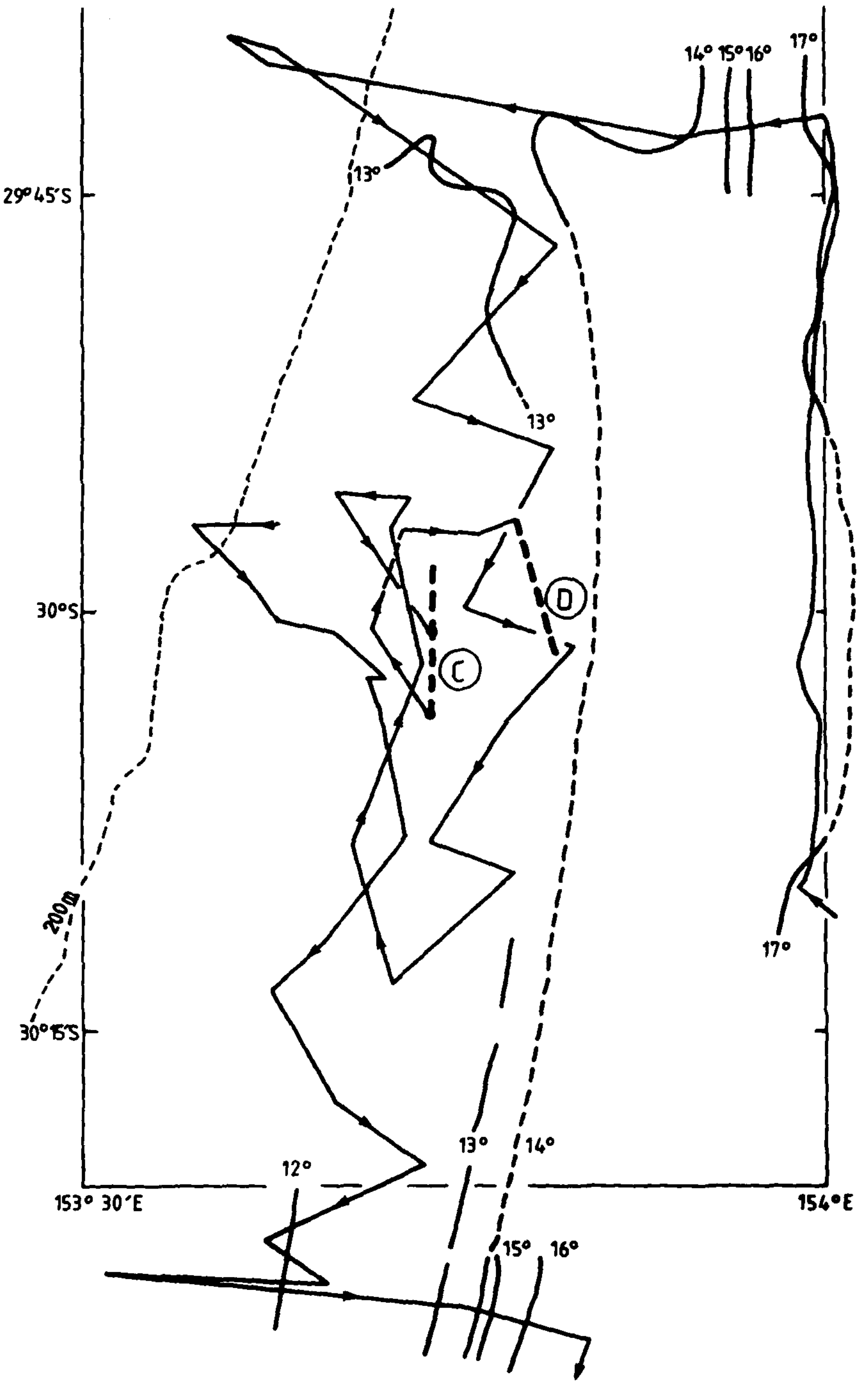

Fig. 4(b). T_{250} (°C) from second cruise (30 - 31 May 1983).

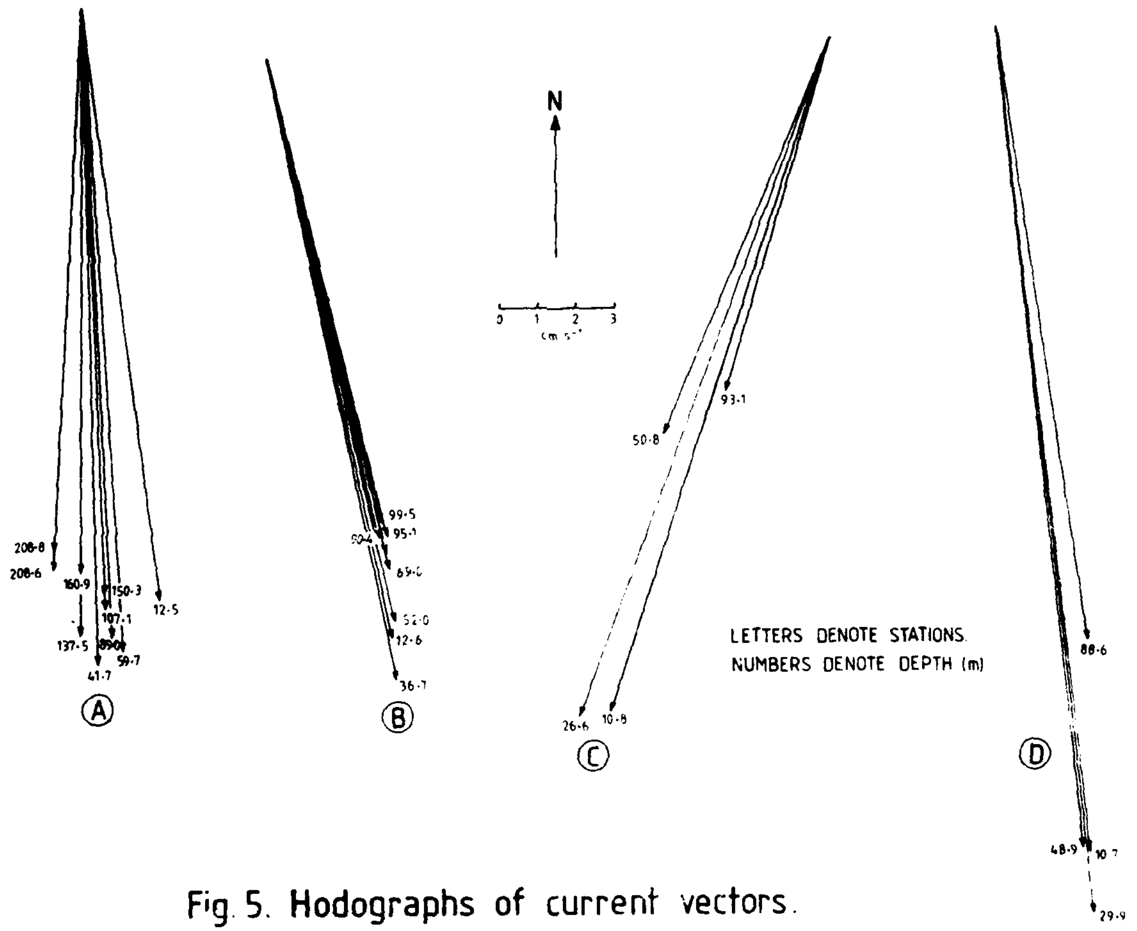

Fig. 5. Hodographs of current vectors.

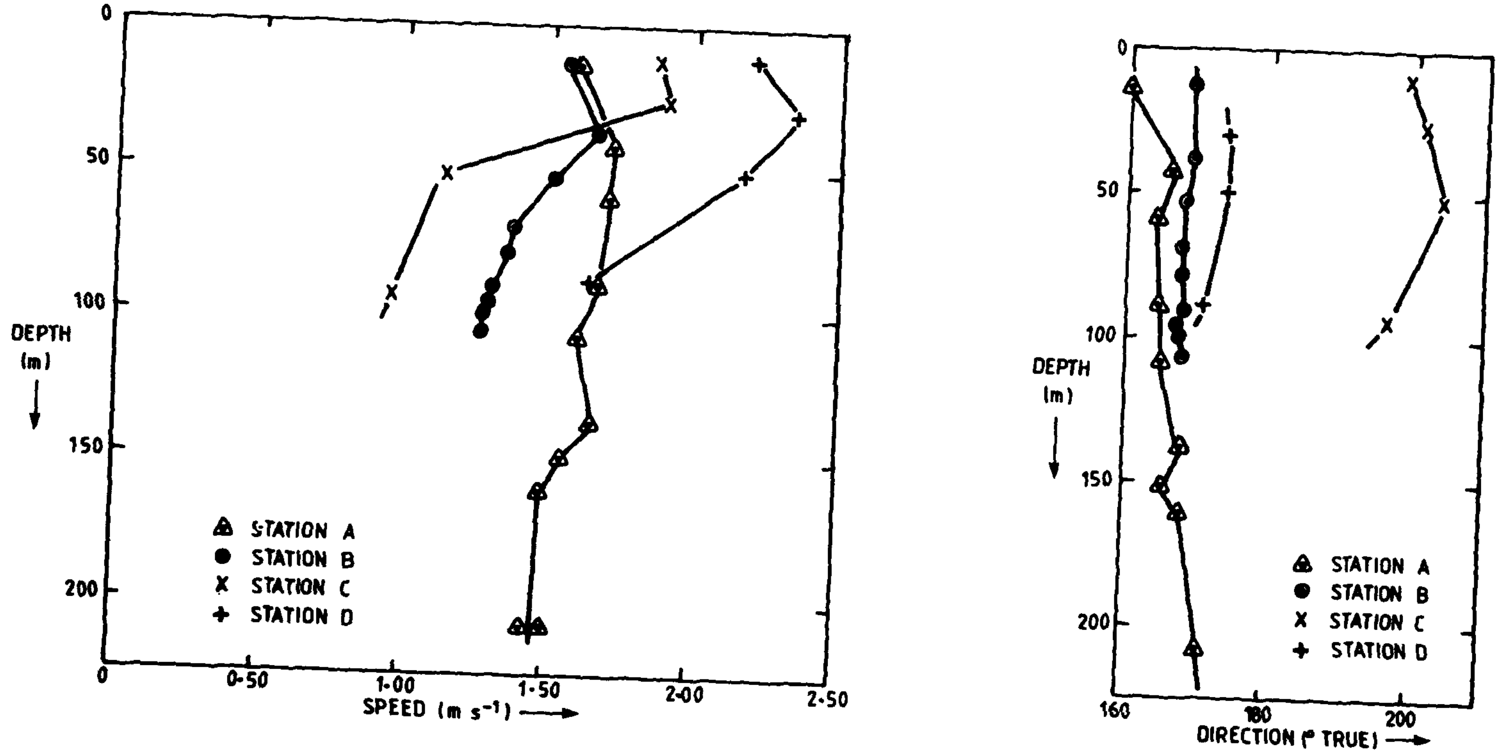

Fig. 6. Current speeds and direction.

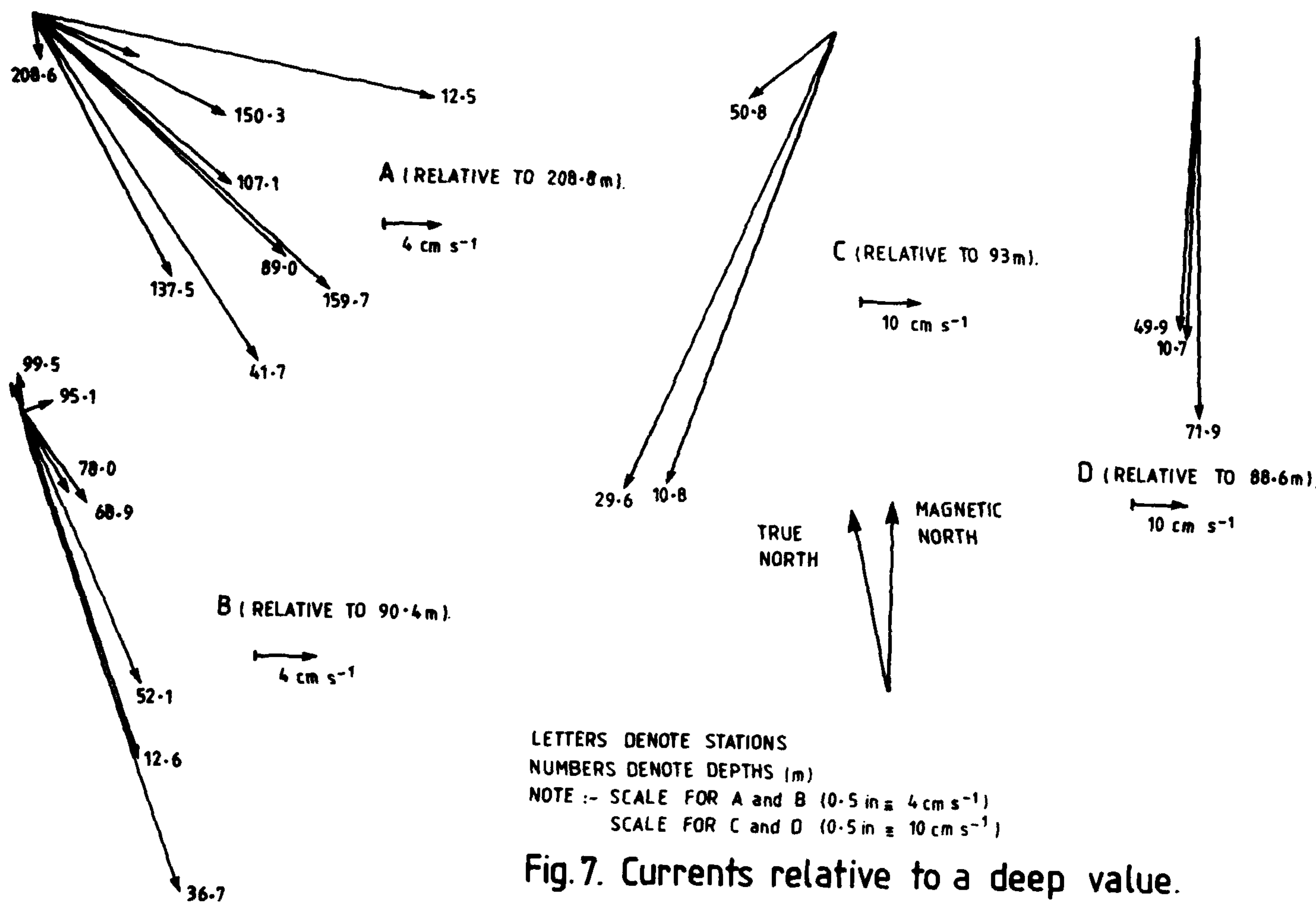

Fig. 7. Currents relative to a deep value.

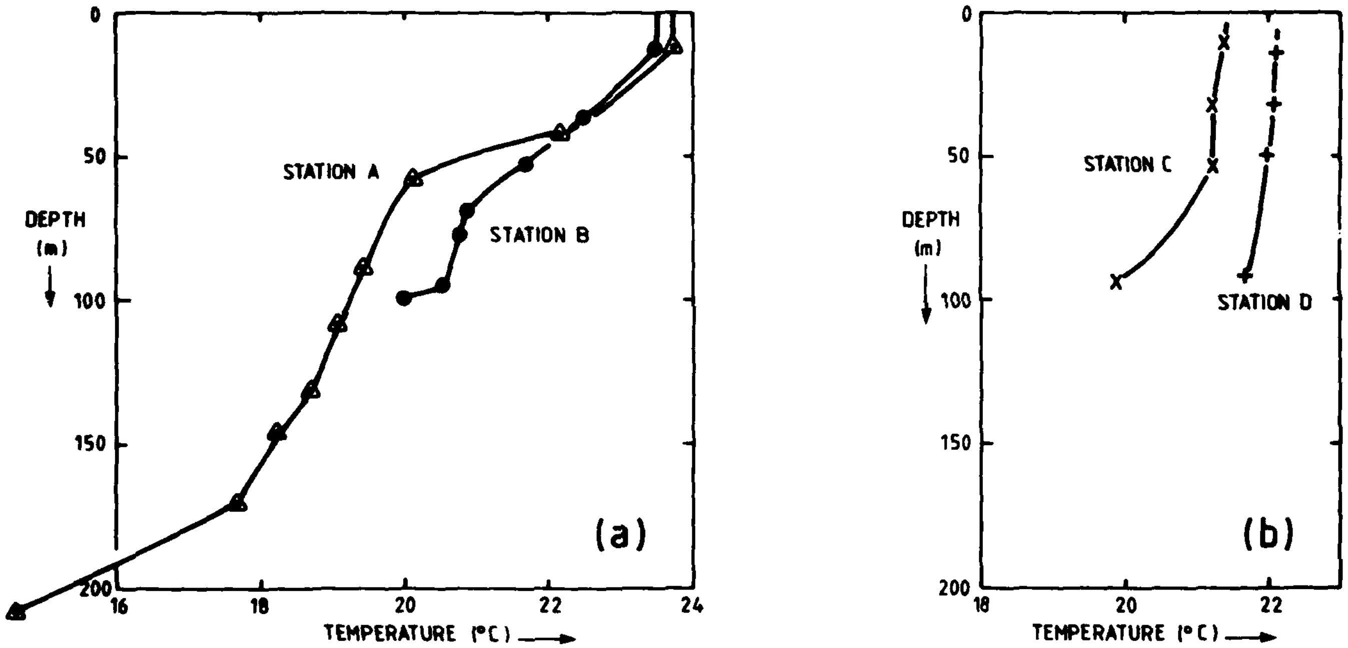

Fig. 8. Temperature profiles from current meter,
(a) first cruise, (b) second cruise.

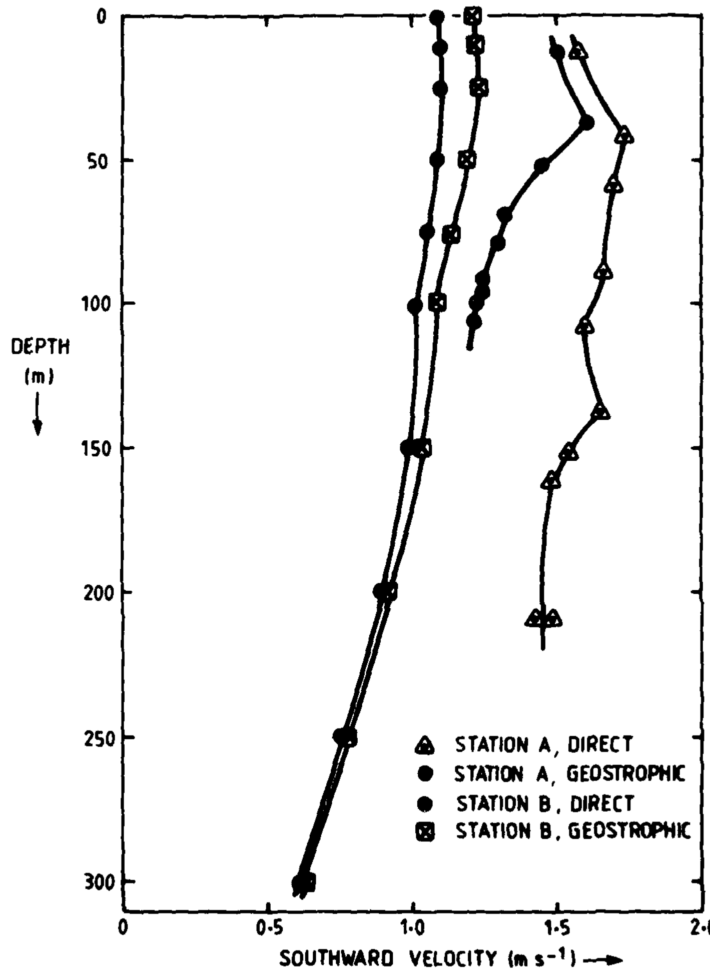

Fig. 9 (a). Comparison between geostrophic and directly measured southward velocity components - first cruise.

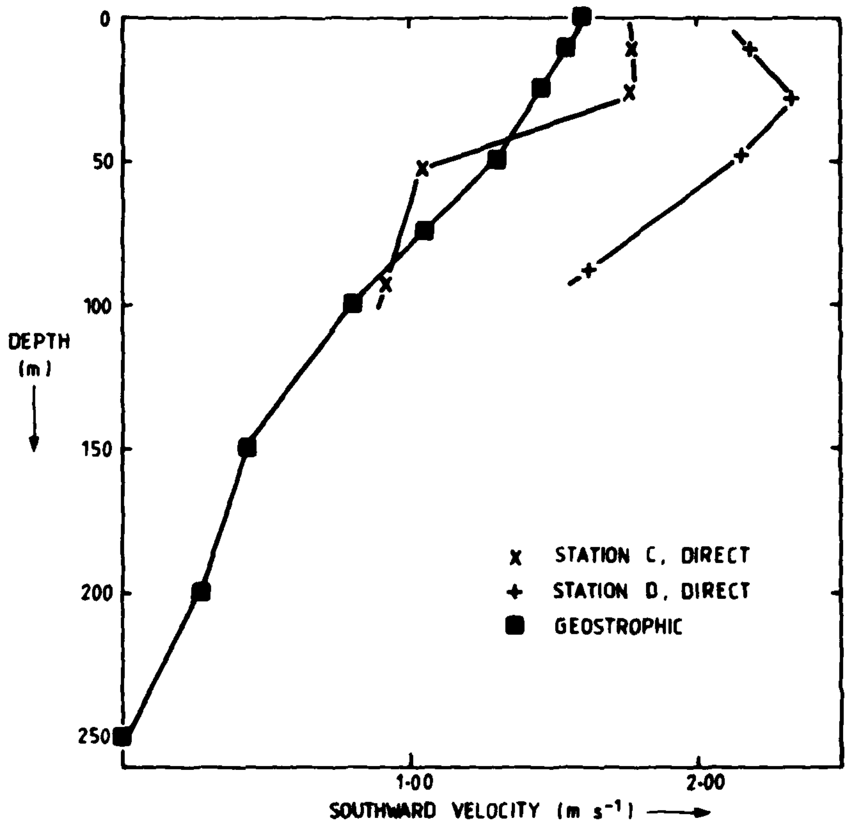

Fig. 9 (b) Comparison between directly measured and geostrophic southward velocity components - second cruise.

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16. Abstract

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